Forest Health Protection

Pacific Southwest Region
Northeastern California Shared Service Area

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To: District Ranger, Warner Mountain Ranger District, Modoc National Forest
Subject: Managing Heterobasidion Root Disease in Bear Soup Project
(Lat 41.318906 Lon -120.280084) (FHP Report NE22-01)

On November 16, 2021, at the request of Peter Hall (WMRD District Silviculturist), Bill Woodruff (Forest Health Protection Plant Pathologist), examined several units in the proposed Bear Soup Project accompanied by Peter Hall and Cameron Cornell (WMRD Culturist). Most units visited are overstocked with white fir. FHP Report NE21-03 stated: "*White fir now exists in dense, multi-aged, and disease infected stands that are highly susceptible to large scale mortality events and stand replacing wildfire.*" The white fir in the Bear Soup have varying amounts of Heterobasidion root disease (HRD) caused by the fungus.

Before entering the Bear-Soup Proposed Project, we stopped on West Warner Road near Brooks Mill to view a private forest (Figures 1, 2 & 3), 280 acres of which was recently logged (Lat 41.283138 Lon -120.310633). Most juniper trees were removed, and the pine was aggressively thinned. The result resembles a seed tree prescription. The managers of this private forest were criticized for this type of harvest. However, managing forests of widely-spaced pine trees has at least seven benefits:

Figure 1. 280 acre private forest (from Google Earth)

#1) From a forest disease perspective, HRD caused by *H. irregulare* will not be a problem for decades in this 280 acres because there are almost no pine-to-pine root contacts remaining through which the Heterobasidion fungus can spread. However, if stumps were not treated with a borate fungicide, the logging may have left a few large HRD infected pine stumps which may spread the disease to nearby pine trees. However, any pine tree that gets HRD

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from infected stumps will not spread HRD to other pines without root connections. Likewise black stain root disease (BSRD), caused by the fungus *Leptographium wageneri* will not be a problem. BSRD has not been reported in the Warner Mountains; but nearby Devils Garden RD, north of Crowder Flat, has a history of BSRD as well as HRD.

Figure 2. Private forest resembling a seed tree prescription.

#2) The Brooks Mill harvest area (Figures 1, 2 & 3) will have no new Western Dwarf Mistletoe (*Arceuthobium campylopodum*) problems for decades. The disease will intensify in pine trees that are currently infected; but no catapulted sticky dwarf mistletoe seed, which cannot be effectively shot more than approximately sixty feet, is likely to reach another pine tree; except for any pine seedlings growing near infected trees. Therefore tree-to-tree spread of the dwarf mistletoe has been virtually eliminated from this harvest area.

#3) A huge advantage of the seed tree-like-harvest is that it will be safe from wildfire for decades. Furthermore, if this area is underburned regularly, wildfire should never be a problem. The millions of forest acres that burned with high intensity fire in California in 2020 and 2021 would not have been devastated by wildfire had they been similarly populated with trees.

Figure 3. Part of the 280 acre private forest at Brooks Mill

#4) Less snow and rain will be intercepted by foliage and prevented, by evaporation, from reaching the forest floor where it is needed to grow trees.

#5) Drought-caused tree mortality should be minimal in the Brooks Mill harvest area. Pine trees on this 280 acres should have enough water to keep them healthy; even during a severe drought.

#6) Natural regeneration of pine seedlings is usually successful on mineral soil that is exposed to lots of sunlight. The 280 acres will likely have pine regeneration in need of thinning in 2 decades.

#7) Natural pine regeneration that results on the 280 acres should carry the genes natural to the site. The original genetic diversity of the pines on this site will be preserved better than with artificial regeneration using seedlings grown from seed collected from selected pine trees grown elsewhere.

NOTE: Some of the above benefits could have been accomplished by leaving two or three times the number of pine trees standing especially in the stand in Figure 3. However, a denser stand would be more likely to carry a crown fire driven by strong winds; and be more susceptible to drought-caused mortality. Also, closer trees would better support the spread of root diseases and dwarf mistletoe.

Managing HRD in the proposed Bear-Soup Project (Figure 4)

Lower elevation units in the proposed Bear-Soup Project were seriously impacted by HRD. These units are overstocked with white fir trees; and most are infected with the root disease fungus *Heterobasidion occidentale.* Higher elevation stands appeared to be less impacted by HRD. Stands with HRD problems have typical symptoms: top-killed (Figure 5); slow growing and dead (Figure 6); and downed white fir (Figure 7). These symptoms were common throughout the Project area. Note: Some of the listed symptoms also can occur in overstocked, drought-stricken true fir forests so HRD must be confirmed.
HRD was confirmed with signs of the fungus: conks and typical delaminated wood (Figure 8 on next page)

Figure 4. Map of proposed Bear-Soup Project

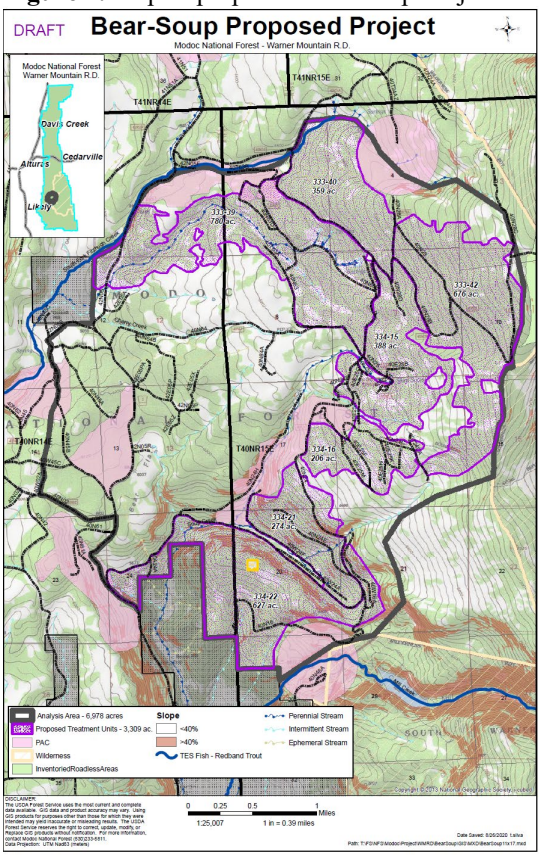

Figure 5. White fir top kill; commonly caused by HRD

Figure 6. HRD symptoms: Slow growing (i.e, rounded not pointed tops) and dead (in background) white fir trees

Figure 7. Downed white fir trees in stand with HRD

In the Bear-Soup Project, Silviculturist Hall hopes to remove most of the old unhealthy white fir trees and leave most young & old pine trees and other conifers. Stands of young white fir trees, with and without suspected HRD, are to be thinned. These actions will effectively **manage** white fir HRD in the Project.

Control of white fir HRD in the project could best be accomplished by removing all white fir infected with *H. occidentale* and regenerating the stands with pine. The fungus would survive in decaying white fir roots and stumps for one or two decades; but, by the time white fir trees repopulate the area (via seed from surrounding forests) HRD should be controlled.

The above action would be most suitable to stands badly impacted by HRD (Figures 5, 6 and 7). HRD could be controlled by removing all the white fir in the lower elevation stands and creating stands similar to that pictured in Figure 2. The result would be a drought and wildfire resilient HRD-free stand. **NOTE: To prevent future pine-HRD, all freshly cut pine stumps greater than 14" diameter created during logging should be treated with a registered borate fungicide.** **SeeAppendix B: *Borate stump treatment recommendations to prevent Heterobasidion root disease***

HRD in high-elevation mostly white fir stands (Figure 9) could be managed with a combination of thinning and patch cuts. The healthier trees would be thinned, and the obvious patches of young white fir would be cleared and planted to pine (e.g. ponderosa, Jeffrey, Washoe, lodgepole, white bark pine). The thinned white fir would continue any HRD already present; however, the effects of HRD in the vigorously growing trees would be reduced as long as tree vigor continued.

If you have any questions regarding this report and/or need additional information, please contact Bill Woodruff at 530-249-7990.

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Figure 8. HRD signs:
Top: Delaminated wood; Bottom: old conk

Figure 9. Young high-elevation white fir stands with HRD

Appendix A: Pest Biology

Heterobasidion root disease

Heterobasidion spp. is a fungus that attacks a wide variety of woody plants. All western conifer species aresusceptible. Madrone (*Arbutus menziesii*), and a few brush species (*Arctostaphylos spp.* and *Artemisia tridentata*) are occasional hosts. Other hardwood species are apparently not infected. The disease has beenreported on all National Forests in California, with incidence particularly high on true fir in northern California, in the eastside pine type forests, and in southern California recreation areas.

Heterobasidion root disease is one of the most important conifer diseases in US Forest Service Region 5, California. Current estimates are that the disease infests about 2 million acres of commercial forestland in California, resulting in an annual volume loss of 19 million cubic feet. Other potential impacts of the disease include increased susceptibility of infected trees to attack by bark beetles, mortality of infected trees presently on the site, theloss of the site for future production, and depletion of vegetative cover and increased probability of tree failure and hazard in recreation areas.

During periods favorable to the fungus, fruiting bodies (conks) form in decayed stumps, under the bark of dead trees, or under the duff at the root collar. New infection centers are initiated when airborne spores produced by the conks land and grow on freshly cut stump surfaces. Infection in true fir may also occur through fire and mechanical wounds, or occasionally, through roots of stumps in the absence of surface colonization. From the infected stump surface, the fungus grows down into the roots and then spreads via root-to-root contact to adjacent live trees, resulting in the formation of large disease centers. These infection centers may continue to enlarge until they reach barriers, such as openings in the stand or groups of resistant plants. In pines, the fungus grows through root cambial tissue to the root crown where it girdlesand kills the tree. In true fir and other non-resinous species, the fungus sometimes kills trees, but more frequently is confined to the heartwood and inner sapwood of the larger roots. It then eventually extends into the heartwood of the lower trunk and causes chronic decay and growth loss.

Heterobasidion root disease in western North America is caused by two species: *Heterobasidion occidentale* and *H. irregulare*. These two species of *Heterobasidion* have major differences in host specificity. *H. irregulare* is pathogenicon ponderosa pine, Jeffrey pine, sugar pine, Coulter pine, incense cedar, western juniper, pinyon, and manzanita. *H. occidentale* is pathogenic on true fir, spruce, and giant sequoia. This host specificity is not apparent in isolates from stumps; with *H. occidentale* being recovered from both pine andtrue fir stumps. These data suggest that infection of host trees is specific, but saprophytic colonization of stumps is not. The fungus may survive in infected roots or stumps for many years. Young conifers established near these stumps often die shortly after their roots contact infected roots in the soil.

Dwarf mistletoe

Dwarf mistletoes (*Arceuthobium* spp.) are parasitic, flowering plants that can only survive on living conifers in the Pinaceae. They obtain most of their nutrients and all of their water and minerals from theirhosts.

Dwarf mistletoes spread by means of seed. In the fall the fruit ripen and fall from the aerial shoots. The seeds are forcibly discharged. The seed is covered with a sticky substance and adheres to whatever it contacts. When a seed lands in a host tree crown, it usually sticks to a needle or twig, where it remains throughout the winter. The following spring the seed germinates and penetrates the twig at the base of the needle. For the next 2-4 years, the parasite grows within the host tissues, developing a root-like system within the inner bark and outer sapwood, and causing the twig or branch to swell. Aerial shoots then develop and bear seed in another 2-4 years.

Dispersal of dwarf mistletoe seeds is limited to the distance the seeds travel after being discharged. From overstory to understory, this is usually 20 to 60 feet, but wind may carry them as far as 100 feet from the source. A rule of thumb is that the seeds can travel a horizontal distance equal to the height of the highest plant in an infected tree. There is some evidence that long distance spread of dwarf mistletoe is occasionally vectored by birds and animals.

Vertical spread within tree crowns of most dwarf mistletoes is limited to less than one foot per year becauseof foliage density. Because of the thin crowns of gray pine, however, the vertical rate of spread has been measured as being greater than 2 feet per year. This rate of spread equaled or exceeded the rate of height growth of infected trees.

Dwarf mistletoes are easy to identify because they are generally exposed to view within a tree's crown. Signs of infection include the yellow green to orange mistletoe plants, basal cups on a branch or stem wherethe plants were attached and detached plants on the ground beneath an infected tree. Symptoms include spindle-shaped branch swellings, witches' brooms in the lower crown, and bole swellings.

Appendix B.

Borate stump treatment recommendations to prevent Heterobasidion root disease

Priorities for stump borate treatments to prevent Heterobasidion Root Disease (HRD) v.4.5
Contact your Forest Health Protection Entomologist or Plant Pathologist for assistance

USFS Region 5 - BORATE STUMP TREATMENT PRIORITY BY FOREST CONDITION and HARVEST ACTIVITY

Priority	HARVEST ACTIVITY in FOREST TYPE and CONDITION	*TREAT WHICH STUMPS?	WHY
Very Low	Salvage high severity burn (nearly all trees killed); plant	NONE	Little connectivity with seedling roots; Most dead roots get infected with competing organisms before seedling roots contact them
Very Low	Clearcut PP/JP, true fir or mixed conifer; any location including roadsides and powerline corridors	NONE	Very low probability of new establishing new infection centers
Very Low	Thin true fir which has widespread light to heavy HRD	NONE	Borates do not cure existing infection
Low	Thin PP/JP with no current or historic pine HRD within 1700 feet	NONE	Very low atmospheric spore concentration
Low	Thin PP/JP in mixed species stands; few >14" PP/JP stumps	NONE	Small pine stumps don't create HRD centers; small roots get infected fast with competing organisms
Low	Thin PP/JP in mixed species stands; few pine-to-pine root contacts	NONE	HRD won't spread from stumps that don't have root contact w/ live trees
Low	Thin Doug-fir; incense cedar; sugar pine; other conifers	NONE	Little evidence of HRD problems
Moderate	Salvage low to moderate severity burn (scattered remaining green trees)*	Consider treating >14" PP/JP and > 24" juniper stumps having possible root contact with high-value PP/JP. Treat true fir stumps in stands with no fir HRD	Borates do not cure existing infections. Treating pine stumps near high-value pine trees can protect residual pine from HRD. Large juniper stumps may facilitate spread to adjacent pines.
High	Any cutting, PP/JP, true fir in roadside and powerline corridors (including hazard tree removal and salvage* in low to moderate severity burns)	Treat all PP/JP and > 24" juniper stumps and true fir stumps >14"	Borates prevent infection; lower tolerance for new HRD centers in these areas. Large juniper stumps may facilitate spread to adjacent pines.
High	Thin PP/JP in mixed species stands; many >14" PP/JP stumps and pine-to-pine root contacts; pine HRD within 1700 feet (or distance to nearest HRD not known)	>14" PP/JP stumps (also >24" juniper stumps if present)	Borates prevent infection. Large juniper stumps may facilitate spread to adjacent pines.
High	Thin true fir with no HRD	> 14" fir stumps	Borates prevent infection
Very High	Thin PP/JP; many >14" stumps; pine HRD within 1700 feet (or distance to nearest HRD not known)	>14" PP/JP stumps	Every stump can start HRD centers
Very High	Recreation and Administrative Sites	>3" conifer stumps	Zero tolerance for new HRD centers in these areas means treating smaller stumps of all conifer species
Very High	Thin giant Sequoia groves; treat conifer stumps within 1700 feet of monarch giant sequoia trees	>3" conifer stumps	Zero tolerance for new HRD centers in these areas means treating smaller stumps of all conifer species

* No need to treat stumps of trees with no needles or stumps of trees killed by fire >18 months earlier